SPGR Sub-Project Completion Report

Project Title

Development of Short Stature High Yielding Wheat Varieties Tolerant to High Temperature

Duration: April 2010 to June 2014

Executing Organization

Wheat Research Centre
Bangladesh Agricultural Research Institute
Gazipur

Submitted to

PIU-BARC, BARC complex
Farmgate, Dhaka-1215

Date of Submission
15 June 2014

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Project completion report

Executive Summary

The goal of this project was to develop new wheat cultivars for the major wheat growing areas especially north-western part of Bangladesh. It was found that most of the elite cultivars grown in country lose significant yield due to heat stress during reproductive phase development. Recent climate changes issues further aggravate the problem due to unpredicted weather events. More than 60% wheat area in Bangladesh is sown late mostly due to delayed harvest of transplanted aman paddy. Wheat is a cold loving plant and grown in the cooler months of winter. It germinates, grows and sets seed at low temperature. Rise in temperature during booting and milking stages causes stress on plant in terms of dwindling fertility, poor seed setting etc. As such, this late-sown wheat faces high temperature stress during grain filling stage which affects grain formation as well as grain development causing significant yield loss. High temperature is therefore, an important production constraint in many tropical and subtropical environments including Bangladesh. Saunders (1988) found a yield reduction of wheat @ 1.3% per hectare per day for each day delay in sowing after November 30, when compared with potential yield of the crop sown in optimum time. It is absolutely clear that high temperature reduces grain yield by directly affecting various yield components like number of spikes and potential spikelet per spike, potential grain number and individual grain weight, etc. On the other hand, most of the varieties released by WRC are nearly 100-110 cm tall. Due to weather hazards, the crops tend to lodge causing significant losses during reproductive stage. During the end of wheat season, rain along with thunderstorms is regular events these days. This hampers grain development and impairs grain quality through disease development in grains thereby reducing total grain yield of wheat.

Major wheat growing region of the developing world has identified heat stress as one of the top research priorities to increase the productivity of wheat. Breeding efforts for the introduction and development of germplasm adapted to warm growing environments of many countries are therefore essential job of breeders. In the past, introduction of heat tolerance to the adapted varieties was not satisfactory due to insufficient knowledge about the physiological and genetic basis of heat tolerance, which was rather a complex phenomenon. Therefore, a massive hybridization and selection program was undertaken in this project to develop short height and high yield potential wheat variety with considerable degree of tolerance to high temperature during grain filling period through new hybridization program along with selection in advance lines. Over 60% of the wheat area in the country was planted late, affecting wheat yield significantly. During the reporting period, 2 outstanding wheat lines were identified to release. More than a dozen new lines were either identified as promising or promoted to various stages of national trials. By disseminating newly developed heat tolerant varieties throughout the country, the yield loss due to late planting is likely to be minimized. Furthermore, it was assumed that 20% yield was reduced by lodging in the presently-developed wheat varieties, which could be overcome by disseminating newly developed short stature variety. Ultimately, wheat productivity and hence the production in the country will be increased and farmers' livelihood will be improved.

1. **Sub-Project Title** : **Development of Short Stature High Yielding Wheat Varieties Tolerant to High Temperature**

2. **Coordinator/Principal Investigator/Co-principal investigator** :

a) **Principal Investigator:**

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4. **Duration :** From May, 2010 to June 2014

5. **Date of approval** (by the Executive Council/signing of LoA) :

6. **Total approved Budget (Taka):** 9542489.00

Total fund received (Tk): 9050213.00

Total fund Spent (Tk): 9050213.00

Unspent/balance fund (Tk.): 00

Reason for the balance : N/A

7. **Justification of undertaking the sub-project** :

High temperature stress during grain filling affects wheat grain formation as well as grain development causing significant yield loss. Yield reduction of wheat @ 1.2% per ha per day for each day delay in sowing after December 1 is documented. Most of the varieties so far developed by WRC, BARI are nearly 100 to 110 cm tall. Due to weather hazards lodging occurs during grain filling stage which causes about 20% yield loss. The present research was undertaken to develop short height varieties that can resist lodging and terminal heat-stress under late sown condition.

8. **Sub-project objectives:**

a) To develop lodging tolerant short stature wheat varieties to resist stormy weather due to climate change

b) To develop heat tolerant wheat varieties to combat the present global warming

9. **Methodology Followed :**

(a) Handling with segregating materials

1st Year

i) A total of 26 F_1 were confirmed and selected from single and top cross.
ii) 31 families were selected out of 149 from F_2 generation
iii) 10 families were selected out of 74 from F_3 generation
iv) 37 families were selected out of 108 from F_4 generation
v) 54 families were selected out of 208 from F_6 generation

2nd year

i) A total of 41 F_1 were confirmed and selected
ii) A total of 72 were selected out of 124 from F_2 generation
iii) A total of 27 were selected out of 46 from F_3 generation
iv) A total of 29 were selected out of 48 from F_4 generation
v) A total of 75 were selected out of 176 from F_6 generation
vi) A total of 18 were selected out of 84 from heat tolerant lines
vii) A total of 3 advance lines were selected out of 20

3rd Year

i) F_2 was spaced-sown at 20m X 6 rows plot under ITS/ILS conditions. Selection was made by following keen observation towards plants with desirable traits (dwarf plants/well-filled grains). Selection of families was first and then individual plants were looked for. Selected Bulk method was adopted. Empirical approach also followed mainly, along with few specific traits was taken under consideration. Seeds was threshed, cleaned and preserved in cool room. Materials with outstanding performance were dealt with special care in order to advance them in short time. It is worthwhile to mention here that every year seeds was collected from plants that were free from diseases (mainly leaf blight-*Bipolaris sorokiniana* and leaf rust-*Puccinia triticina* Eriks). These two are the devastating wheat diseases at the moment. Both breeder and pathologist was worked together to select disease free plants with desirable traits.

(b) Handling exotic germplasms/advanced generations

1st Year

i) 72 heat tolerant lines were collected from different international sources (CIMMYT, ICARDA, Nepal etc)
ii) The trials were evaluated in Dinajpur, Joydebpur and Jessore with two replications.
iii) 17 good lines were selected based on their agronomic performance along with pathological scoring

2nd year

i) 84 heat tolerant lines were collected & planted in three locations with two replications.

ii) Selected 17 lines were planted in adaptive trials with two replications in Dinajpur, Joydebpur and Jessore.

iii) Heat tolerant traits of those lines were thoroughly evaluated at field and lab conditions.

iv) Simultaneously, heat tolerant lines were collected from different sources (home and abroad)

3rd year

i) Best four (BAW 1135, BAW 1151, BAW 1161 and BAW 1170) early maturing medium short lines were selected for CVD and 13 short statured, early maturing lines were selected for evaluation in AYT/PYT next year.

ii) Seven good lines were placed for crossing block.

iii) Seed of selected lines was preserved in cool room for next year

iv) The best three lines were placed in DUS test nursery for characterization

4th year

i) BAW 1151 and BAW 1161 were tested under irrigated timely seeding condition in Multi Location Testing (MLT) trials at Dinajpur, Rajshahi, Jessore, Comolla, Tangail and Jamalpur with check variety Shatabdi. Two advanced lines (BAW 1135 and BAW 1170) were selected and included in CVD will be evaluated in MLT trials net year. Six short stature, early maturing lines were selected for evaluation in AYT and 16 selected lines will be evaluate PYT next year.

10 Results and discussion

EXP. 1. HYBRIDIZATION AND CONFIRMATION OF F_1S

A total of 150 single, top and limited back crosses (50 crosses per year) were made and 150 F_1s were confirmed under sub-project. F_1s were evaluated based on earliness, short stature, disease severity against leaf rust and leaf blight etc. Selected F_1s were advanced in subsequent generations.

EXP. 2. EVALUATION AND SELECTION IN DIFFERENT FILIAL GENERATIONS

A total of 172 F_2, 87 F_3, 64 F_4, 72F_5 (1500 single plant) and 176 F_6 were selected during sub-project period. Selection were done based on earliness, disease severity of BpLB and leaf rust, plant height, vigor of single plant, etc. The filial generations were tested and evaluated at Wheat Research Centre (WRC) Dinajpur, Regional Wheat Research Centre (RWRS) Joydebpur and Regional Agricultural Research Station (RARS) Jessore. Thirty to fifty individual plants per family in F_2, 25-30 single plant in F_3 and F_4 were selected and two to five spikes from each selected plants were collected and bulked them to grow in subsequent segregating generation next year. In F_5, single selected plant collected separately and kept them also separately. Among the selected bulks/individual plants, there were many ones with outstanding field performance, disease tolerance and excellent visual grain characteristics. The following achievements were presented in Table 2.1.

Table 2.1. Final selection in different filial generations at WRC, in project period

Filial Generations/ Head Rows	Families Tested	Families Selected	Remarks
F_2	172	72	30 to 50 plants per family
F_3	87	27	25 to 30 plants per family
F_4	64	29	25 to 30 plants per family
F_5	74	52	1500 single plant
F_6	176	75	Whole plot bulk
Total	573	255	

EXP: 3 HEAT TOLERANT WHEAT YIELD TRIALS (HTWYT)

Native and exotic germplasm of different sources were put into this trial in the name of HTWYT along with four checks and all are planted at two dates. The data presented in Table 3.1 showed that the genotypes differed significantly for heading and maturity days. The genotypes E-30, E-42 and E-43 were relatively earlier in heading than all the checks in across the seeding dates. The genotypes were significantly influenced by seeding dates for plant height. In optimum seeding condition, three genotypes were found shorter than the all four checks. The genotypes E-30, E-42 and E-43 were found significantly shorter height than all the checks at late seeding condition.

Table 3.1. Influence of seeding date on heading, maturity and plant height of the selected genotypes of HTWYT.

Genotype	Heading		Maturity		Plant height	
	Optimum	Late	Optimum	Late	Optimum	Late
Shat.	72	69	110	103	103	95
Prod.	67	63	107	96	97	89
BARI25	66	62	106	96	97	92
BARI26	66	63	106	95	95	88
E-5	64	61	108	97	99	91
E-9	69	64	108	97	94	89
E-13	67	63	105	95	99	92
E-15	67	63	105	96	97	86
E-16	67	64	108	96	100	93
E-18	68	65	106	99	98	98
E-30	62	60	104	93	80	76
E-33	61	62	102	95	86	86
E-41	63	62	107	98	96	89
E-42	60	60	103	94	85	82
E-43	61	59	103	93	90	82
E-55	71	70	111	102	103	94
E-61	66	74	111	104	99	89
E-64	66	65	107	98	94	92
E-75	66	65	107	98	96	98
E-77	71	70	111	103	103	97
E-79	72	69	112	102	103	96
E-81	71	70	112	102	101	98
LSD (5%)	1.50		3.31		4.71	
CV (%)	2.0		2.8		4.5	
	**		*		**	

Grains per spike, 1000 grain weight and yield were significantly influenced by seeding dates. The highest number of grains per spike in optimum seeding dates was recorded in E-61 whereas in late seeding condition E-64 was produced highest number of grains per spike. The higher numbers of grains per spike in both optimum and late seeding condition over the checks were obtained from the genotypes E-55, E-61, E-64, E-75, E-77 and E-81.

The highest TGW under both seeding condition was achieved by entry-41(Table 3.2). Remarkable higher yield from all the checks was attained in E-13(5050 kg ha^{-1}), E-15(5117 kg ha^{-1}), E-16 (4971 kg ha^{-1}), E-55(5036 kg ha^{-1}), E-61(5224 kg ha^{-1}) and E-79 (5219 kg ha^{-1}) under optimum seeding condition whereas considerable higher yield over all the checks was obtained from the genotype E-13, E-33, E-42, E-43, E-64 and E-75 under late seeding conditions. The genotypes E-

61(5224 kg ha^{-1}) and E-75(4628 kg ha^{-1}) was the highest yielder in optimum and late seeding condition respectively.

Table 3.2 Effect of seeding date on grains $spike^{-1}$, 1000-grain weight and of the selected genotypes of HTWYT

Genotype	Grains $spike^{-1}$ (no.)		1000-grain weight (g)		Yield (Kg/ha)	
	Optimum	Late	Optimum	Late	Optimum	Late
Shatabdi	50.1	48.3	50.7	41.1	4837	4009
Prodip	51.9	46.7	54.6	41.6	4809	3223
BARI Gom 25	46.4	44.1	50.9	44.0	4823	3879
BARI Gom 26	53.6	51.7	44.3	40.1	4744	3746
E-5	44.3	44.7	48.9	42.4	4655	3873
E-9	46.8	43.4	49.8	39.8	4767	3529
E-13	49.9	45.9	51.4	47.1	5050	4292
E-15	44.3	42.4	52.8	46.3	5117	3633
E-16	48.1	45.1	53.1	46.2	4971	3959
E-18	45.4	45.4	42.6	37.3	4598	3948
E-30	43.2	38.4	51.7	43.6	4728	3700
E-33	46.2	54.0	48.2	36.1	4587	4166
E-41	45.1	45.4	57.1	51.2	4433	3608
E-42	41.4	45.5	48.9	41.5	4369	4266
E-43	42.8	42.7	45.9	40.8	4470	4303
E-55	55.5	54.3	39.8	31.2	5036	3378
E-61	63.4	57.5	42.3	35.2	5224	3862
E-64	60.0	63.4	40.0	34.4	4772	4186
E-75	59.2	61.4	41.5	37.2	4368	4628
E-77	62.1	61.6	38.6	32.4	4113	3688
E-79	51.6	48.3	41.2	30.5	5219	3742
E-81	58.7	60.6	40.8	31.1	4765	3727
LSD (5%)	5.89		3.17		374.6	
CV (%)	10.5		6.6		8.1	
	*		**		**	

Yield, heading days, short duration, short height, heat tolerant, physical grain characteristics, disease reaction, sterility etc. were the most important selection criteria, so these were given most priority during selection. The data presented in Table 4. showed that the genotypes differed significantly for

heading and maturity over location. The genotypes E-30, E-33, E-42 and E-43 at Dinajpur, Joydebpur and Jessore were comparatively earlier in heading than all of the checks at optimum and late seeding condition. The genotypes E-30 and E-33 at Dinajpur, Joydebpur and Jessore were comparatively earlier in maturity than all the checks in both seeding condition whereas E-42 and E-43 were found earlier in maturity in Joydebpur and Jessore than the checks.

Table 3.3. Interaction effects of different seeding times and genotypes on heading days and maturity in over locations.

Genotype	Heading (days)						Maturity (days)					
	Dinajpur		Joydebpur		Jessore		Dinajpur		Joydebpur		Jessore	
	Opti.	Late	Opti.	Late	Opti.	Late	Opti.	Late	Opti.	Late	Opti.	Late
Shatabdi	78	76	68	65	69	68	114	109	107	98	110	101
Prodip	72	70	62	60	67	61	109	103	103	92	108	95
BARI Gom 25	71	68	61	59	66	60	109	104	104	90	104	95
BARI Gom 26	75	71	61	59	63	60	112	104	102	89	104	94
E-5	72	67	58	58	63	58	110	105	104	91	110	95
E-9	75	69	66	64	66	60	113	105	107	93	105	94
E-13	73	69	62	61	67	59	110	104	103	88	103	94
E-15	72	68	65	63	64	59	110	105	103	92	102	93
E-16	72	70	64	63	65	60	111	105	105	90	107	95
E-18	72	69	67	64	67	63	112	105	103	96	102	96
E-30	68	66	59	56	61	58	108	102	102	84	103	93
E-33	68	67	60	54	60	58	107	102	102	88	98	93
E-41	71	68	58	55	64	60	111	104	102	93	107	97
E-42	69	66	57	52	58	58	110	102	100	87	100	93
E-43	70	67	56	54	58	57	109	103	100	84	99	93
E-55	80	75	67	65	70	68	116	106	106	101	113	100
E-61	80	77	73	68	63	55	116	108	110	102	107	102
E-64	74	69	63	61	65	62	110	105	105	93	108	98
E-75	73	70	62	59	65	63	111	106	105	90	105	98
E-77	79	74	67	66	71	68	114	106	107	102	114	101
E-79	81	74	66	62	71	69	116	105	107	100	114	101
E-81	79	76	67	67	69	66	117	107	107	100	113	101
				**						**		
LSD (5%)				2.60						5.73		
CV (%)				2.0						2.8		

The genotypes were significantly influenced by seeding dates for plant height and grains per spike. In both optimum and late seeding condition three genotypes (E-30, E-33, and E-42) in Dinajpur, Joydebpur and Jessore were found shorter than all the checks, whereas E-43 were found shorter in Joydebpur and Jessore (Table 3.3). The genotypes (E-61, E-64, E-75 and E-77) were produced higher number of grains per spike in Dinajpur, Joydebpur and Jessore than all the checks in optimum and late seeding condition.

Table 3.3. Interaction effects of different seeding times and genotypes on plant height and grains/spike in over location.

Genotype	Plant height (cm)						Grains/ Spike					
	Dinajpur		Joydebpur		Jessore		Dinajpur		Joydebpur		Jessore	
	Optimum	Late	Optimum	Late	Optimum	Late	Optimum	Late	Optimum	Late	Optimum	Late
Shatabdi	105	97	98	95	107	95	49.9	49.6	52.5	48.8	48.0	46.5
Prodip	105	95	86	85	101	86	54.7	49.0	50.1	46.1	51.0	45.0
BARI25	108	96	87	89	98	93	53.8	41.2	41.4	48.0	44.0	43.0
BARI26	102	91	86	85	97	88	59.8	57.5	48.7	49.6	52.5	48.0
E-5	104	99	93	86	99	88	46.2	43.9	42.4	48.6	44.5	41.5
E-9	98	100	90	82	95	86	46.2	39.5	49.1	48.2	45.0	42.5
E-13	106	98	95	90	96	89	48.6	44.4	55.7	50.3	45.5	43.0
E-15	105	90	91	82	95	86	46.7	45.3	43.7	40.3	42.5	41.5
E-16	106	101	92	88	101	91	52.3	46.4	46.9	52.0	45.0	37.0
E-18	106	106	94	88	100	94	50.0	50.1	45.4	49.2	41.0	37.0
E-30	88	79	73	70	82	78	38.5	35.7	49.2	43.9	42.0	35.5
E-33	89	89	85	81	89	83	54.6	51.0	36.4	56.4	47.5	54.5
E-41	107	96	84	85	97	85	50.3	42.1	42.1	45.1	43.0	49.0
E-42	96	86	78	71	87	81	49.1	46.0	35.1	47.6	40.0	43.0
E-43	102	88	83	82	87	78	47.1	49.6	38.9	40.0	42.5	38.5
E-55	107	102	94	91	109	91	53.4	56.7	58.2	56.3	55.0	50.0
E-61	100	92	94	82	103	93	65.8	68.0	61.4	55.2	63.0	49.5
E-64	100	95	84	88	97	93	64.7	68.8	54.3	60.6	61.0	61.0
E-75	101	103	91	95	96	98	63.7	62.2	57.8	65.2	56.0	57.0
E-77	105	96	95	95	109	101	66.6	64.3	63.7	61.6	56.0	59.0
E-79	107	100	94	90	107	97	51.9	46.3	51.4	49.5	51.5	49.0
E-81	104	105	94	91	107	99	53.5	61.3	64.2	60.0	58.5	60.5
LSD (5%)	8.15						10.20					
CV (%)	4.5						10.5					

Table 3.4. 1000-grain weight (TGW) and yield over locations as influenced by seeding time during of HTWYT

Genotype	1000-grain weight (g)						Yield (Kg ha^{-1})					
	Dinajpur		Joydebpur		Jessore		Dinajpur		Joydebpur		Jessore	
	Opt.	Late	Opt.	Late	Opt.	Late	Opt.	Late	Opt.	Late	Opt.	Late
SHATABDI	51.8	46.1	52.9	40.2	47.5	37.0	5955	4735	4713	4560	4743	3633
PRODIP	55.1	37.5	56.8	41.8	52.0	45.5	5675	3345	3853	2628	4900	3698
BARI Gom 25	53.4	45.3	53.3	42.6	46.0	44.0	6700	4005	3498	3740	4273	3893
BARI Gom 26	48.2	42.8	46.2	39.4	38.5	38.0	6000	3960	4065	3825	4168	3453
E-5	51.4	42.9	48.9	42.5	46.5	42.0	5150	4495	3593	3020	5223	4103
E-9	52.6	38.7	51.4	39.1	45.5	41.5	5975	4665	4323	3173	4003	2750
E-13	56.2	54.0	50.0	43.9	48.0	43.5	6460	4970	4165	3908	4525	3998
E-15	58.0	51.3	51.4	45.2	49.0	42.5	6400	4415	4530	3053	4420	3430
E-16	56.9	52.6	51.9	41.9	50.5	44.0	5680	4330	4280	3500	4953	4048
E-18	47.9	41.8	43.5	32.7	36.5	37.5	5780	4490	4103	3945	3913	3410
E-30	57.6	44.5	52.5	42.9	45.0	43.5	5425	4065	4113	2403	4645	4633
E-33	48.6	36.1	49.2	35.2	47.0	37.0	5475	5025	3710	3235	4575	4238
E-41	60.6	51.7	59.7	49.4	53.0	52.5	5115	4375	3603	3180	4583	3270
E-42	50.4	46.3	53.2	40.2	43.0	38.0	6975	5300	2450	3573	3683	3925
E-43	46.9	43.8	48.8	38.2	42.0	40.5	5875	5348	3220	3520	4315	4040
E-55	45.3	36.0	39.2	31.3	35.0	26.5	7270	4510	3593	3160	4245	2463
E-61	49.5	36.5	38.0	33.7	39.5	35.5	5520	6045	5038	2895	5115	3645
E-64	41.7	36.5	39.2	32.7	39.0	34.0	5475	5355	3830	3258	5010	3945
E-75	46.6	39.7	41.8	36.4	36.0	35.5	5320	5670	4078	4018	3705	4195
E-77	41.0	34.0	39.8	33.1	35.0	30.0	4700	4760	4660	3090	2978	3215
E-79	44.2	35.1	41.8	30.3	37.5	26.0	7125	4980	4573	3360	3960	2885
E-81	43.9	31.9	38.6	30.8	40.0	30.5	6270	4690	4353	3050	3673	3440
LSD (5%)	NS						648.9					
CV (%)	6.6						8.1					

The genotypes were significantly influenced by seeding dates for grain yield presented in Table 3.4. The higher TGW were achieved in E-41 than the checks in optimum and late seeding condition for all the locations.

The genotype E-42 and E-79 at Dinajpur and E-16 and E-64 at Jessore were produced higher yield in optimum and late seeding condition than the checks. The highest yield was recorded in E-55 (7270 kg ha^{-1}) and E-61 (6045 kg ha^{-1}) in optimum and late seeding condition in Dinajpur respectively.

Effect of seeding time on canopy temperature in vegetative stage (Fig. 3.1.) indicated that the canopy temperature recorded in selected genotypes were lower than all the checks in both optimum and late seeding times. In reproductive stage, all the selected genotypes showed lower canopy temperature compared to all checks in optimum and late seeding conditions (Fig.3.2).

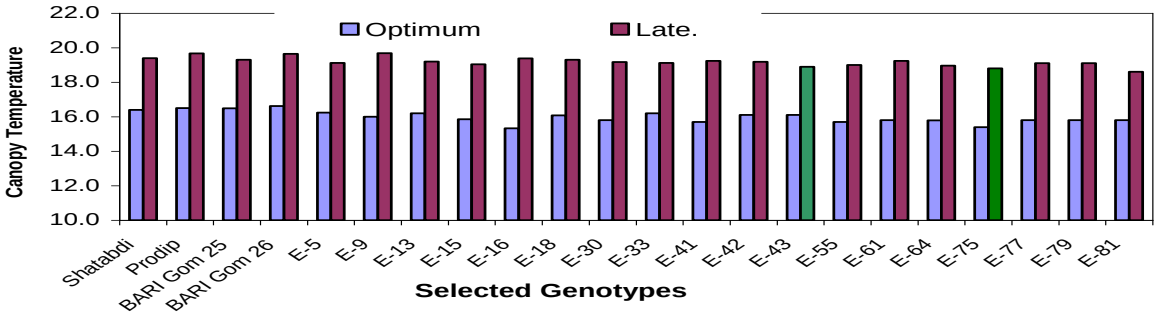

Fig.3.1. Effects of seeding times on canopy temperature (°c) in vegetative stage of the selected genotypes of HTWYT.

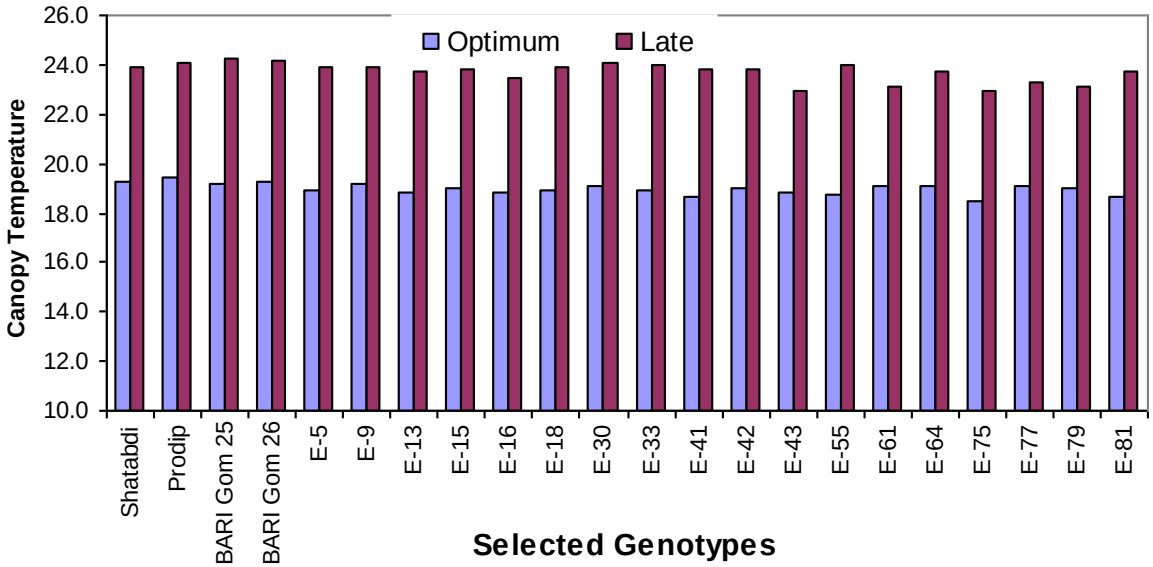

Fig. 3.2. Canopy temperature (°c) of selected genotypes was influenced by the seeding times.

Effect of seeding times on chlorophyll content (Fig. 3.3) indicated that higher chlorophyll was recorded in E-43 and E-75 under late seeding compare to optimum. Most of the genotypes posses higher chlorophyll compare to all the checks.

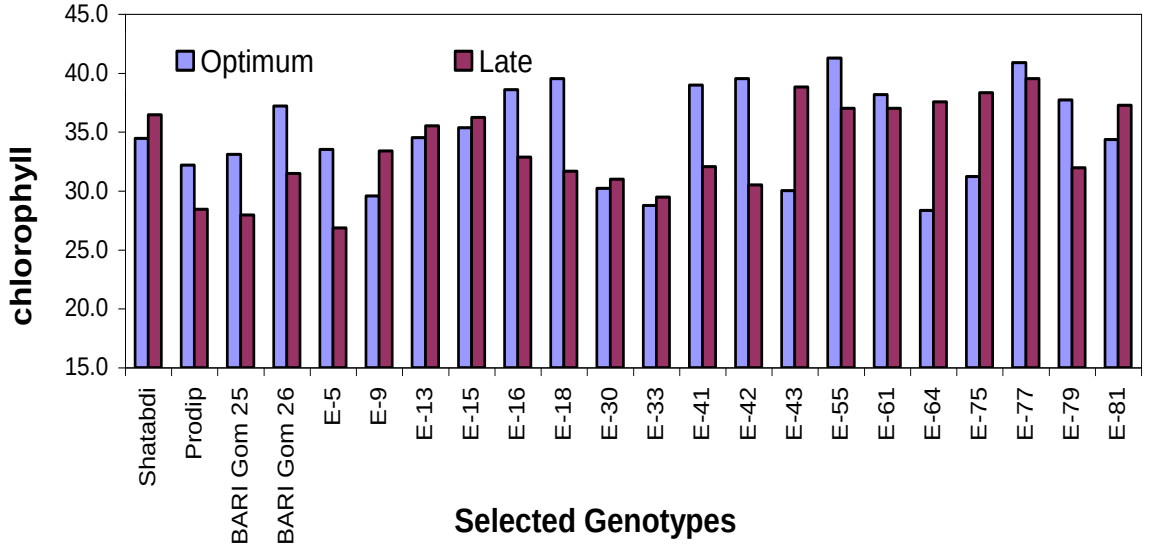

Fig 3.3. Effects of seeding times on Chlorophyll content of the selected genotypes of HTWYT.

EXP 4. ADAPTIVE TRIAL WITH SELECTED HEAT TOLERANT LINES

Yield, heading days, short duration, short height, heat tolerant, physical grain characteristics, disease reaction, sterility etc. were the most important selection criteria, so these were given most priority during selection. The data presented in Table 4.1 showed that, the genotypes differed significantly for heading over location. The genotypes E-12, E-13, E-14, E-17 and E-19 at Dinajpur, Joydebpur and Jessore were comparatively earlier in heading than all of the checks at optimum, late and very late seeding condition.

Table 4.1. Interaction effects of different seeding time and genotypes on heading days in over locations of Adaptive Trials.

Genotypes	Dinajpur			Joydebpur			Jessore			
	Optimum	Late	Very late	Optimum	Late	Very late	Optimum	Late	Very late	Mean
Shatabdi	77	74	69	62	63	63	71	71	67	68
Prodip	72	69	66	62	61	60	64	62	59	64
BARI Gom 26	73	71	68	62	59	61	63	64	61	64
E-4	74	69	67	62	59	61	70	65	61	65
E-5	74	70	67	62	60	61	70	66	62	66
E-6	77	72	70	65	63	63	75	70	65	69
E-7	75	70	68	62	59	61	64	65	61	65
E-8	74	69	66	62	61	62	72	67	62	66
E-9	75	71	69	62	60	61	69	66	62	66
E-10	74	69	66	62	60	60	72	66	60	65
E-11	79	72	66	66	66	65	76	72	66	70
E-12	71	67	65	60	56	58	60	59	58	62
E-13	70	67	66	60	59	59	61	59	59	62
E-14	70	67	65	61	56	58	60	59	57	61
E-15	71	68	66	61	57	58	65	60	59	62
E-16	74	74	69	64	63	65	70	69	67	68
E-17	71	67	64	60	56	58	61	59	56	61
E-18	72	68	66	62	58	58	63	60	58	63
E-19	70	67	65	60	57	58	62	60	60	62
E-20	71	68	66	62	58	59	64	61	60	63
CV (%)	1.12									
LSD	2.22									

The data presented in Table 4.2 showed that the genotypes differed significantly for maturity days over location. The genotypes E-14, E-15, E-17, E- 19 and E-20 at Dinajpur, E-4, E-10, E-14, E-15, E-16, E-17 and E-19 at Joydebpur and E-13, E-17, E-19 and E-20 were comparatively earlier in maturity than all checks at optimum seeding condition. In late seeding condition, genotype E-4, E-10, E-12, E-13, E-14, E-15, E-17, E-19 and E-20 at Joydebpur, and E-13, E-14 at Jessore were relatively earlier in maturity than the checks. All of the genotypes were comparatively earlier in maturity than the check variety Shatabdi at Dinajpur and Jessore in very late seeding condition.

Table 4.2. Interaction effect of different seeding time and genotypes on maturity days in over locations

Entry	Dinajpur			Joydebpur			Jessore			
	Opt.	Late	Very late	Opt.	Late	Very late	Opt.	Late	Very late	Mean
Shatabdi	114	107	101	102	96	91	114	99	93	102
Prodip	108	101	96	103	92	92	109	96	88	98
BARI Gom-26	110	103	99	102	91	90	107	96	91	99
E-4	109	101	97	99	89	89	109	98	90	98
E-5	110	102	100	105	92	92	113	98	92	100
E-6	111	103	100	104	91	92	112	98	92	100
E-7	111	103	99	103	91	92	111	98	91	100
E-8	112	104	100	108	98	91	114	99	93	102
E-9	110	105	100	103	92	92	111	100	92	101
E-10	110	102	98	101	89	93	110	97	90	99
E-11	114	106	101	105	100	92	113	97	91	102
E-12	113	105	100	102	88	85	108	96	90	99
E-13	108	102	98	100	90	92	105	95	90	98
E-14	105	102	98	101	90	89	107	95	88	97
E-15	107	103	99	98	88	91	107	96	90	98
E-16	111	107	101	92	99	88	113	100	93	100
E-17	107	102	96	99	88	91	106	96	88	97
E-18	112	104	100	105	94	91	112	98	92	101
E-19	106	102	98	98	88	88	105	97	92	97
E-20	107	103	98	100	90	88	104	98	91	98
CV (%)	1.56									
LSD	3.10									

The genotypes were significantly influenced by seeding dates for plant height. In optimum seeding condition, four genotypes (E-11, E-14, E-18, E-20) in Dinajpur, two genotypes (E-7, E-18) in Joydebpur and seven genotypes (E-9, E-13, E-15, E-17, E-18, E-19, E-20) were found shorter height than all the checks. In late seeding condition, three genotypes (E-17, E-18, E-20) in Dinajpur, two genotypes (E-14, E-20) in Joydebpur and six genotypes (E-9, E-13, E-15, E-19, E-40, E-65, E-68, E-69 and E-72) in Jessore were found shorter than the checks. In very late seeding condition, three

genotypes (E-17, 18 and E-20) in Dinajpur and Jessore and two genotypes (E-18 and E-20) in Joydebpur were found shorter than the checks.

Table 4.3. Interaction effects of different seeding time and genotypes on plant height (cm) over locations of Adaptive Trials.

Entry	Dinajpur			Joydebpur			Jessore			Mean
	Optimum	Late	Very late	Optimum	Late	Very late	Optimum	Late	Very late	
Shatabdi	107	105	98	101	94	91	110	96	96	99
Prodip	100	97	88	96	81	82	108	89	86	92
BARI Gom 26	101	93	93	90	79	84	99	92	90	91
E-4	105	98	95	99	85	88	102	97	93	95
E-5	102	97	96	93	89	82	104	96	98	95
E-6	101	98	98	99	95	86	102	96	92	96
E-7	100	94	98	89	81	82	99	94	94	92
E-8	102	99	97	101	90	90	107	101	96	98
E-9	103	99	94	92	87	89	99	97	96	95
E-10	100	96	91	95	88	87	100	87	90	93
E-11	99	94	95	90	86	87	102	97	91	93
E-12	106	106	99	98	88	92	107	100	101	99
E-13	102	100	96	95	82	89	97	93	98	94
E-14	97	96	92	94	79	82	100	88	88	90
E-15	100	96	96	92	85	82	97	89	87	91
E-16	105	102	100	97	86	89	108	94	97	97
E-17	100	92	87	91	82	85	96	87	82	89
E-18	95	89	84	88	81	81	92	80	82	86
E-19	104	100	98	90	89	95	98	98	98	97
E-20	96	92	88	93	77	79	93	86	81	87
CV (%)	2.903									
LSD	5.73									

The data presented in Table 4.4 showed that the genotypes were non significant for grains/spike over location. The higher numbers of grains per spike were obtained from the genotype E-7 in Dinajpur and Jessore in optimum, late and very late seeding condition over the checks. But in Joydebpur, four genotypes (E-5, E-11, E-14 and E-15) were given higher number of grains/spike than the checks in optimum seeding condition and maximum genotypes were given higher number of grains/spike in late and very late seeding condition than the check Shatabdi.

Table 4.4. Interaction effects of different seeding time and genotypes on grains/spike (number) over locations of Adaptive Trial.

Entry	Dinajpur			Joydebpur			Jessore			
	Sowing time									
	Optimum	Late	Very late	Optimum	Late	Very late	Optimum	Late	Very late	Mean
Shatabdi	48	46	38	56	47	46	54	47	37	46
Prodip	51	47	55	52	52	45	58	42	38	49
BARI Gom-26	63	50	48	58	56	52	59	53	44	54
E-4	56	50	49	58	50	47	57	44	36	50
E-5	56	50	40	60	48	48	54	43	32	48
E-6	50	52	47	58	51	48	50	48	34	49
E-7	67	63	57	58	45	55	66	59	43	57
E-8	52	49	46	54	47	50	53	45	39	48
E-9	55	50	46	55	47	53	48	38	31	47
E-10	54	48	45	48	45	48	54	43	39	47
E-11	59	54	47	66	52	50	55	46	34	51
E-12	56	48	45	47	41	46	44	40	35	44
E-13	53	50	50	54	48	55	57	47	36	50
E-14	53	49	44	61	53	50	53	47	38	50
E-15	58	54	48	61	52	47	51	42	40	50
E-16	53	50	44	54	49	46	51	39	31	46
E-17	54	50	47	54	44	60	55	52	41	51
E-18	60	51	51	59	54	52	47	41	43	51
E-19	60	55	48	58	52	53	54	45	43	52
E-20	43	38	36	38	36	41	42	35	36	38
CV (%)	8.6									
LSD	-									

The genotypes were significantly influenced by seeding time for 1000-grain weight over location (Table 11). In optimum seeding condition, eight genotypes (E-13, E-14, E-15, E-16, E-17, E-18,E-19 and E-20) were found higher thousand grain weight in Dinajpur than the check Shatabdi whereas, two genotypes (E-14 and E-20) in Joydebpur and three genotypes (E-14, E-17 and E-20) in Jessore were found higher thousand grain weight than all the checks. In late seeding condition, genotype (E-20) in Dinajpur, genotypes (E-14) in Joydebpur were found higher thousand grain weight than the checks. In very late seeding condition, six genotypes (E-14, E-15, E-16, E-18, E-19 and E-20) in Dinajpur, three genotypes (E-16, E-17 and E-20) in Joydebpur and two genotypes (E-17 and E-20) in Jessore were found higher thousand grain weight than the checks. The genotypes (E-14 and E-20) were found higher mean thousand grain weight than the checks.

Table 4.5. Interaction effects of different seeding time and genotypes on 1000-grain weight (TGW) over locations.

Entry	Dinajpur			Joydebpur			Jessore			Mean
	Optimum	Late	Very late	Optimum	Late	Very late	Optimum	Late	Very late	
Shatabdi	48.3	46.6	35.4	47.8	46.6	38.3	44.0	34.0	32.0	41.5
Prodip	60.1	44.9	21.6	49.7	48.0	39.2	47.0	43.0	41.0	43.8
BARI Gom-26	47.6	41.0	31.8	37.5	42.1	35.6	44.0	33.5	38.0	39.0
E-4	41.0	37.0	28.7	38.1	35.2	29.7	36.5	28.0	27.5	33.5
E-5	43.3	37.0	31.4	39.9	43.4	31.9	38.5	33.0	31.0	36.6
E-6	44.1	33.5	26.3	34.2	36.4	32.4	35.0	28.0	30.5	33.4
E-7	42.5	36.2	30.2	36.9	38.2	30.1	36.0	33.0	32.0	35.0
E-8	37.3	31.1	26.2	30.6	32.9	26.4	33.0	25.0	24.0	29.6
E-9	44.5	35.5	27.1	40.4	35.4	35.2	42.0	30.5	37.5	36.5
E-10	40.0	31.8	26.5	35.9	38.1	32.2	39.5	25.0	27.0	32.9
E-11	42.1	25.6	24.9	35.9	34.6	29.1	37.5	18.0	20.5	29.8
E-12	43.0	36.8	33.0	37.0	36.8	31.0	34.5	25.5	28.0	34.0
E-13	51.9	38.0	23.3	42.5	46.1	35.3	45.5	33.5	37.0	39.2
E-14	57.7	44.2	39.5	54.2	46.9	38.9	48.0	40.5	34.0	44.9
E-15	52.1	43.5	36.3	45.2	42.4	37.8	43.5	37.5	39.5	42.0
E-16	50.2	45.7	36.6	48.3	44.9	39.8	44.0	32.0	32.0	41.5
E-17	53.9	39.4	28.2	48.2	45.8	39.3	50.5	42.5	43.0	43.4
E-18	48.4	46.4	37.1	42.2	39.8	37.1	40.5	38.0	38.5	40.9
E-19	49.4	39.8	40.5	40.9	42.1	36.8	34.5	34.5	37.5	39.6
E-20	59.9	50.2	39.6	55.4	46.3	48.5	56.5	39.5	43.0	48.8
CV (%)	6.9									
LSD	5.17									

The Table 4.6 presented that the effect of genotypes, seeding time and their interaction over locations were significantly influenced for yield. The genotype E-6 at Dinajpur (5630 kg ha^{-1}) and Joydebpur (3580 kg/ha) and Shatabdi (6320 kg ha^{-1}) at Jessore were produced highest yield in optimum seeding condition; whereas the highest yield was produced E-16 (4015 kg ha^{-1}) at Dinajpur followed by Shatabdi (3910 kg ha^{-1}), E-18 (3700 kg ha^{-1}) and E-12 (3530 kg ha^{-1}), and Shatabdi at Joydebpur (3210kg ha^{-1}) followed by E-10 (2727 kg ha^{-1}) and E-6 (2718 kg ha^{-1}) and Jessore E-13(4905 kg ha^{-1}) in late seeding condition. In very late seeding condition, the highest yield was recorded in E-7 (2980 kg ha^{-1}) followed by E-6 (2830 kg ha^{-1}), E-17 (2825 kg ha^{-1}) and E-9 (2800 kg ha^{-1}) at Dinajpur, and E-19 (2403 kg ha^{-1}) followed by E-9 (2370 kg ha^{-1}), E-6 (2320 kg ha^{-1}), Shatabdi (2220 kg ha^{-1}), E-5 (2183 kg ha^{-1}) and E-4 (2110 kg ha^{-1}) at Joydebpur and at Jessore E-19 (4265 kg ha^{-1}), followed by E-17 (4140 kg ha^{-1}), E-15 (4085 kg ha^{-1}), E-13 (4010 kg ha^{-1}) and E-6 (3765 kg ha^{-1}).

Table 4.6. Interaction effect of different seeding time and genotypes on yield (kg ha^{-1}) over locations

Entry	Dinajpur			Joydebpur			Jessore			Mean
	Sowing time									
	Optimum	Late	Very late	Optimum	Late	Very late	Optimum	Late	Very late	
Shatabdi	5045	3910	2560	3270	3210	2220	6320	3755	3085	3708
Prodip	4550	2415	1835	3020	2303	1657	5435	3705	2875	3088
BARI Gom-26	5095	2890	2390	3427	2450	1810	4990	4260	3395	3412
E-4	5035	2798	2480	3380	2603	2110	4895	3760	2945	3334
E-5	4935	2825	2740	3063	2187	2183	6245	4200	3290	3519
E-6	5630	3190	2830	3580	2718	2320	5000	4130	3765	3685
E-7	5145	3160	2980	2587	2510	1910	5285	3955	3315	3427
E-8	4510	2915	2435	2857	2313	2093	4935	3525	3050	3181
E-9	4425	3340	2800	2907	2313	2370	4575	3940	2745	3268
E-10	5440	3120	2100	2930	2727	2140	5135	3280	2980	3317
E-11	4485	2075	2195	2873	2343	1987	4765	2125	2065	2768
E-12	4315	3530	2615	2263	2257	1587	3870	3955	3055	3050
E-13	4865	2640	1270	2960	2603	1900	5230	4905	4010	3376
E-14	3905	2470	1535	3200	2210	1770	5040	4030	3235	3044
E-15	4470	3160	2440	2663	2173	1850	4640	4100	4085	3287
E-16	4530	4015	2695	2840	2593	2080	5795	3810	3120	3498
E-17	4785	2430	2825	2660	2257	1703	5475	4300	4140	3397
E-18	4990	3700	2595	3283	2377	1967	4865	4300	3275	3484
E-19	4955	3270	2595	3280	2260	2403	5165	4125	4265	3591
E-20	4310	2555	2600	2750	2363	1680	4245	3890	3315	3079
CV (%)	8.8									
LSD	574									

EXP 5. ADAPTIVE TRIAL WITH CANDIDATE WHEAT VARIETIES

Before release a variety the advance lines are tested at farmers' field to evaluate their adaptation to wide ranges of environments. During this stage the genotypes are also evaluated by the Variety Evaluation Committee (VCE) of National Seed Board (NSB). The report of this committee is essential to the Technical Committee to release a variety. Therefore, the adaptive trial was conducted at Dinajpur like different regions of the country. Two outstanding lines of wheat viz. BAW 1151 and BAW 1161 plus widely grown commercial cultivar Shatabdi as a check variety were evaluated in farmers' fields and research station of Dinajpur, Jessore, Jamalpur, Rajshahi, OFRD Comilla and a farmers' field at Tangail. The trial was laid out in RCB design with 3 replications. Unit plot size was 5m x 4m. Recommended package of practices were followed to raise the crop under irrigated condition. The seeds were sown during 26 November to 011 December 2013. Grain yield was estimated from whole plot harvest. Data on yield and other yield contributing characters were also recorded. Data were analyzed by RCB design. Each trial was considered as a dispersed replication. The trial was conducted in Dinajpur, Jamalpur, Tangail, Comilla, Jessore and Rajshahi under irrigated timely sown condition.

The proposed lines out yielded the check variety Shatabdi and were 7-10 days earlier and 20-25 cm shorter than the check variety. The mean performances of the proposed lines were given below.

Table 5.1. The performances of the proposed lines and check variety over locations, 2013-14.

Locations	Genotypes (Yield: t ha^{-1})		
	SHATABDI	**BAW 1151**	**BAW1161**
Dinajpur-1	4.32	5.52	5.65
Dinajpur-2	3.72	4.56	4.59
Comilla-1	4.66	4.99	5.28
Comilla-2	3.54	3.62	4.15
Tangail	2.67	3.58	4.30
Jessore-1	3.98	4.34	4.50
Jessore-2	3.90	3.40	4.12
Jamalpur-1	2.77	3.43	3.85
Jamalpur-2	3.70	4.38	3.96
Rajshahi-1	4.15	3.70	5.19
Rajshahi-2	4.13	3.90	5.00

There was significant yield difference compared to check variety Shatabdi were observed presented in Fig. 5.1. The highest yield was recorded in BAW 1161 (4.57 t ha^{-1}) over the location, followed by BAW 1151(4.17 t ha^{-1}) the lowest in check variety Shatabdi (3.75 t ha^{-1}). Considering the overall performance of two advanced lines, variety evaluation committee of different regions have recommended to National Technical Committee (NTC) of NSB to release.

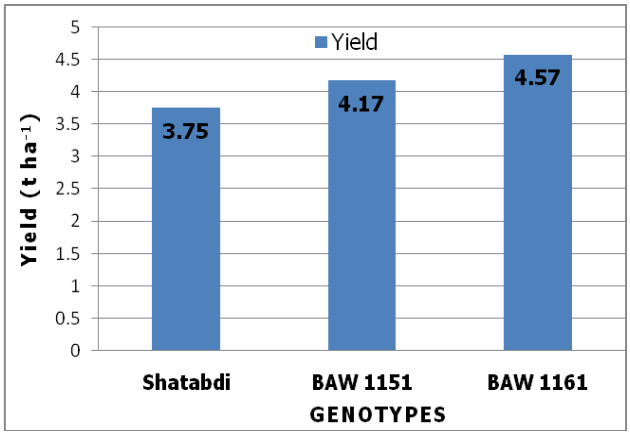

Fig:5.1. Yield performance of genotypes over location

11. Research Highlights:

- Hybridization
- Evaluation and selection in F_1 generations
- Selection in Different Filial Generations (F_2 – F_6)
- Evaluation and selection in collected exotic germplasm
- Evaluation and selection in collected local adapted germplasm
- Performance studies of advanced short statured heat tolerant lines
- Adaptive trial with candidate wheat varieties
- DUS (Distinctness, Uniformity, Stability) were made.

➢

12. **Major Attainments** ***(in relation to the set objectives)*** **:**

a) Technical : Output, Outcome and Impact

Sl. No	Major technical activities performed in respect of the set objectives	Output(i.e product obtained, visible, measurable)	Outcome(short term effect of the research)	Impact(long term effect of the research)	Remarks(reason,if anything otherwise plus any other)
1	Hybridization, Confirmation and selection of F_1s generations	A total of 150 crosses were made and 150 F_1 were selected	150 F_1 lines	Create variation in local germplasm	
2	Selection in segregating generation	573 segregate	255 segregate	Increased selected variant	
3	Germplasm collection	156 lines	34 lines	Enrich local germplasm	
4	Heat Tolerant Wheat Yield Trial	84 lines	18 Short, heat tolerant lines	Increased short and heat tolerant lines	
5	Adaptive Trial with candidate lines	4 lines (BAW 1135, 1151, 1161, 1170)	4 lines	New varieties	

b) Procurement

Sl. No	Approved provisions of Procurement (list major items)	Achievement	% of achievement	Remarks (reason, if anything otherwise)
1	SPAD meter	3	100	
2	IR Gun	3	100	
3	Grain moisture meter	2	100	
4	Single head thresher	1	100	
5	PTOS	3	100	
6	Hot Water bath	1	100	
7	Distill water plant	1	100	
8	Dehumidifier	4	100	
9	EC Meter	2	100	
10	Desk top computer	2	100	
11	Motorcycle	1	100	
12	Furniture (5 items)	5	100	
13	Digital camera	1	100	
14	Bicycle	2	100	

c. HRD/ Training/Workshop

Title (e.g Ph.D/MS/ Trainings, workshops conducted etc.)	Target	Attainments	No. of participants	Benefit of the workshop	Remarks reason, if anything otherwise)
Workshop	1	1	70	Lesson learn of DAE personnel	

d. Financial

Sl. No	Major Head	Fund received (Tk.)	Expenditure (Tk.)	Balance/Unspent (Tk)	Remarks (reason, if anything otherwise)
1	Contractual Staff Salary	1817516.00	1995980.00		
2	Field Research / Lab expenses and supplies	2383880.00	2496734.00		
3	Operating Expenses	532878.00	611035.34		
4	Vehicle Hire and Fuel, Oil and Maintenance	634381.00	668990.40		
5	Training/Workshop/Seminar etc.	100000.00	100000.00		
6	Publications and printing	65897.00	85900.00		
7	Contingencies	226661.00	300549.26		
8	Capital Expenses	3289000.00	3283300.00		

e. Materials developed/Publications made :

A short bulletin with important features for heat stress and lodging tolerance in wheat is under processing.

13. Sub-project Auditing (cover all types of audit performed)

Types of Audit (e.g BARC/Implementing agency/FAPAD/World Bank/others)	**Major observations/issues/objections raised, if any**	**Status at the sub-project end**	**Remarks**
FAPAD	N/A		
World Bank	N/A		
BARI	N/A		

14. Reporting

Report type	Actual date of submission(s)	Total Number(s)	Remarks(if anything otherwise)
a. Inception report	26-08-2010	26-08-2010	
b. Monthly reports*	03-06-2010, 04-07-2010, 03-08-2010, 05-09-2010, 03-10-2010, 13-01-11, 03-11-10, 15-02-11, 16-03-11, 17-04-11,17-05-2011, 15-06-2011, 9-07-2011, 9-08-2011, 12-09-2011, 12-10-2011, 15-11-2011, 15-12-2011, 4-01-2012, 7-02-2012, 14-03-2012, 26-04-2012, 13-05-2012, 12-06-2012, 14-07-2012, 12-08-12, 3-9-12, 9-10-12,15-10-12, 8-11-12, 13-12-12	36	
c. Statement of expdts.(SoE)*	10-10-10, 13-10-10 ,09-11-10, 06-12-10, 13-01-11, 15-02-11, 20-03-11, 10-04-11, 17-05-2011, 15-06-2011, 9-07-2011, 9-08-2011, 12-09-2011, 12-10-2011, 15-11-2011, 15-12-2011, 4-01-2012, 7-02-2012, 14-03-2012, 26-04-2012, 13-05-2012, 12-06-2012, 14-07-2012, 12-08-2012, 3-9-12, 9-10-12,15-10-12, 8-11-12, 13-12-12	36	
d. Quarterly report(s)*	03-08- 2010, 15-02-11,15-02-2011, 03-08-2011,28-02-2012, 25-12-12		
e. Six monthly report	November 2010, May 2011, December 2011, August 12, Feb, 13		
f. Procurement plan	Aug.2010/Jan. 12	,	
g. Annual research program format	As per date		
h. Field Monitoring Report(s)**	3		

** Provide all the dates since start to end.*

*** Conducted at the local level by implementing agencies.*

15. Problems/Constraints(bullet points- max. 5 nos.) :N/A

16. Suggestion for future, if any :